SITE CHARACTERIZATION/REMEDIAL INVESTIGATION REPORT AOI 10

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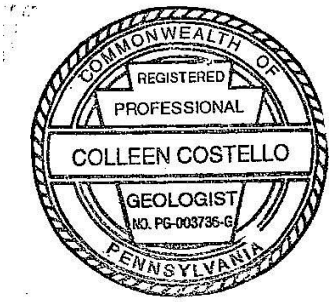

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1.0 INTRODUCTION

A Current Conditions Report and Comprehensive Remedial Plan (CCR) prepared by Sunoco Inc. (R&M) (Sunoco), dated June 30, 2004, proposed Phase II site characterization and corrective action activities for Sunoco's Philadelphia Refinery (refinery), including preparation of site characterization reports (SCRs) for individual Areas of Interest (AOIs). The CCR presented a prioritization of all eleven AOIs based on specific risk factors. To date, site characterization activities have been completed for nine AOIs at the Refinery. These include: AOI 1 (Belmont Terminal, #1 and #2 Tank Farm), AOI 2 (Point Breeze Processing Area), AOI 3 (Impoundment Area), AOI 4 (#4 Tank Farm), AOI 5 (Girard Point South Tank Field Area), AOI 6 (Girard Point Chemicals Processing Area), AOI 7 (Girard Point Fuels Processing Area), AOI 8 (Point Breeze Process Area North Yard) and AOI 9 (Schuylkill River Tank Farm). Site Characterization Work Plans and Site Characterization Reports for these nine AOIs were submitted to the Pennsylvania Department of Environment Protection (PADEP) and the United States Environmental Protection Agency (EPA).

This Site Characterization/Remedial Investigation Report (SCR/RIR) has been prepared by Langan Engineering and Environmental Services, Inc. (Langan), on behalf of Sunoco for AOI 10 at the refinery. This report has been prepared in accordance with the 2003 Consent Order and Agreement (CO&A) between Sunoco and PADEP and the CCR.

AOI 10, also known as the Point Breeze West Yard (West Yard), is comprised of approximately 80 acres and is located west of the Schuylkill River and south of Passyunk Avenue (Figures 1 and 2). AOI 10 is mostly open space and bounded by Passyunk Avenue to the north-northwest, the Schuylkill River to the east-southeast, and industrial properties to the south and west. Lands Creek, a small tributary of the Schuylkill River, traverses the southern portion of AOI 10 (Figure 1). The current and future intended use of AOI 10 is non-residential.

Four past disposal areas (PDAs 1 through 4) exist in AOI 10. These past disposal areas consist of former lagoons and landfills that received wastes from the refinery under Atlantic Richfield Company ownership during the 1950s and 1960s. PDAs 1 and 2 were capped with clay materials and PDAs 3 and 4 were capped with clay and vegetative cover materials in the 1980s. The PDAs were investigated as part of the 1992 Resource, Conservation and Recovery Act (RCRA) Facility Investigation (RFI) performed by ENSR Consulting and Engineering (ENSR). As part of the RFI activities, the PDAs were grouped into one corrective action management unit (CAMU). This CAMU is the only RCRA waste management unit in AOI 10.

1.1 Site History and Background

The refinery is located in southwest Philadelphia. The refinery has a long history of petroleum transportation, storage, and processing. The oldest portion of the refinery started petroleum-related activities in the 1860s when the Atlantic Refining Company established an oil distribution center. In the 1900s, crude oil processing began and full-scale gasoline production was initiated during World War II. In addition to refining crude oil, various chemicals, such as acids and ammonia were also produced at the refinery for a time. Current operations at the refinery are limited to the production of fuels and basic petrochemicals for the chemical industry. The current and historic uses of AOI 10 are illustrated in a figure provided in Appendix A.

In addition to the PDAs, historic use areas in AOI 10 include a tankage area and associated pump houses in the northeast portion and two fuel docks along the eastern boundary with the river. The structures associated with the tanks and pump houses were demolished prior to 2005. Currently, activities in AOI 10 include maintenance of an existing Sunoco pipeline that is mostly above grade and extends along much of the northern AOI 10 boundary, and an aboveground manifold area that connects underground and aboveground lines between the refinery and the refinery's Schuylkill River Tank Farm.

AOI 10 is located within a fenced and secured area to prevent unauthorized access. Prior to any work being completed within AOI 10, appropriate work permits, safety and security measures must be approved by Sunoco refinery personnel. AOI 10 is under the control of Sunoco's health and safety administrative procedures and is regulated by the Occupational Safety and Health Administration (OSHA). Direct contact to site soils (soils greater than two feet beneath the ground surface) is controlled by Sunoco's on-site permit and personal protective equipment (PPE) procedures.

1.2 Selection of Constituents of Concern and Applicable Standards

The soil and groundwater constituents of concern (COCs) for AOI 10 are listed in Tables 1a and 1b of this report. These COCs are the same as those listed in the CCR, with the exception of two additional constituents: 1,2,4-trimethylbenze and 1,3,5-

trimethylbenzene. These two constituents were added to the list of COCs based on the PADEP's recent revisions to the petroleum short list of constituents.

Soil samples collected in and around the CAMU were analyzed for Target Compound List (TCL) volatile constituents, semi-volatile constituents, and Target Analyte List (TAL) metals to characterize the waste materials in the CAMU. Surface water samples were analyzed for a modified site COC list that includes total and dissolved TAL metals and hardness as listed in Table 1c. Sediment samples were analyzed for a modified site COC list that included TAL metals, total organic carbon (TOC), particle grain size, and pH as listed in Table 1d.

Data collected from the above-listed activities were evaluated following PA Act 2 procedures as part of the site characterization process.

Media of Concern

The media of concern for AOI 10 include groundwater, soil, surface water, and sediment. The potential indoor air quality and off-site vapor migration exposure pathways were evaluated through application of PADEP's vapor intrusion guidance, even though no vapor intrusion receptors currently exist onsite.

Act 2 Remediation Standards

The approach for attaining Act 2 remediation standards for the media of concern is described below by media.

Groundwater

Groundwater sample results were screened against the PADEP non-residential, used-aquifer (TDS<2,500) statewide health groundwater medium-specific concentrations (MSCs). As summarized in the CCR, where constituent concentrations are above these statewide health MSCs, Sunoco evaluated application of the site-specific remediation standard using either the pathway elimination or calculated risk-based standard options.

Shallow Soil – 0 to 2 Feet Interval

Shallow (0-2 feet) soil samples were collected at each soil boring/well location inside and outside the CAMU areas that represents a potential complete direct contact exposure pathway to site workers (e.g., unpaved areas). These shallow soil results

were screened against the PADEP, non-residential statewide health soil MSCs. Based on the depth to groundwater at AOI 10, all shallow soil samples collected were unsaturated; therefore, the MSCs for unsaturated conditions were used when evaluating these data.

As summarized in the CCR, where constituent concentrations are above the MSCs, Sunoco evaluated application of the site-specific remediation standard using either the pathway elimination or calculated risk-based standard options.

Soil – 2 to 15 Feet Interval

The site-specific remediation standard using the pathway elimination option was applied for soil between 2 and 15 feet beneath the ground surface within the boundaries of AOI 10 based on Sunoco's existing permit program governing excavations. This permit program serves as an institutional control that prevents potential exposure to impacted soils greater than two feet beneath the ground surface. Soil at this depth is evaluated through the groundwater data.

Soil borings extending beyond two feet were advanced inside and around the perimeters of the CAMU areas to characterize the waste material in the CAMU and the soil conditions beneath and around the perimeters. Samples of the waste materials in the CAMU areas were collected, as were soil samples from beneath the waste. These waste and soil samples were screened against the PADEP, non-residential statewide health soil MSCs. Based on the depth to groundwater at AOI 10, all soil samples collected at depths greater than two feet were considered to be saturated; therefore, the MSCs for saturated conditions were used when evaluating these data.

Vapor Intrusion into Indoor Air

Currently there are no buildings in AOI 10. Therefore, there are no potential receptors to vapor intrusion (VI) into indoor air within AOI 10. Soil and groundwater samples collected in AOI 10 were evaluated in accordance with the current Act 2 Vapor Intrusion Guidance, where applicable. The groundwater table is less than five feet below the ground surface in several areas of AOI 10. Soil and groundwater samples collected in these areas were not screened against the default screening numbers in the guidance. In addition, the waste in the CAMU areas is not considered soil-like; therefore, analytical data from the waste samples was not screened.

The refinery is regulated under OSHA; therefore, the appropriate OSHA standard was applied when evaluating the potential indoor air pathway. No soil gas sampling was completed as part of this site characterization, but if future development is proposed for the areas that were not able to be screened using the PADEP vapor screening criteria, soil gas sampling would be completed in these areas.

Surface Water

Surface water sample results collected in Lands Creek were screened against the Pennsylvania State Code Title 25, Chapter 93 Water Quality Standards. Direct contact to surface water in Lands Creek is prevented by Sunoco's existing permitting and PPE program; therefore surface water quality was evaluated with respect to potential ecological receptors.

Sediment

Sediment sample results from samples collected in Lands Creek were screened using the Severe Ecological Level (SEL) and Low Ecological Level (LEL) sediment screening criteria. Below is a summary of the hierarchy used in selecting the appropriate screening criteria.

- SEL
    - Calculated site-specific SEL using site-specific total organic carbon values.
    - Ontario sediment SEL (if no site specific SEL was available).
- LEL
    - Ontario sediment LEL.
    - National Oceanic Atmospheric Administration (NOAA) effects range low (ERL) sediment benchmark (if no Ontario sediment LEL was available).
    - Sediment EPA Region 5 sediment benchmark (if no NOAA ERL was available).

Direct contact to sediment in Lands Creek is prevented by Sunoco's existing permitting and PPE program; therefore sediment quality was evaluated with respect to potential ecological receptors.

1.3 Overview of Investigative Framework and Remedial Approach for AOI 10

The current remediation program for the Refinery is performed under the 2003 CO&A between PADEP and Sunoco. In April 2004, the PADEP and EPA signed an agreement entitled "One Cleanup Program Memorandum of Agreement (MOA or One-Cleanup Program)," which clarifies how sites remediated under Pennsylvania's Act 2 program may satisfy RCRA corrective action requirements through characterization and attainment of Act 2 remediation standards pursuant to Pennsylvania's Act 2. On November 22, 2005, Sunoco and its representatives met with officials of the PADEP and EPA to discuss the applicability of the Sunoco Philadelphia Refinery to the One Cleanup Program. During the November 22, 2005 meeting, all parties agreed that the One Cleanup Program would benefit the project by merging the remediation obligations under the various programs into one streamlined approach which would be conducted under the existing 2003 CO&A.

As a follow up to the November 22, 2005 meeting, Sunoco submitted a letter dated December 2, 2005 to EPA and PADEP documenting the discussions at the meeting. Sunoco submitted a notice of intent to remediate (NIR) for the Refinery, excluding the Belmont Terminal, to the PADEP on October 12, 2006 and held a public involvement meeting in South Philadelphia on September 19, 2007. A copy of this NIR and the Act 2 report notifications for this SCR/RIR are included in Appendix B.

On March 5, 2009, Sunoco and its representatives met again with EPA to discuss Sunoco Philadelphia Refinery's remediation progress and path forward under the One Clean-Up Program. As a follow up to the meeting, Sunoco submitted a letter dated March 11, 2009 to EPA and PADEP documenting the discussions at the meeting. The major points of this letter are as follows:

- EPA will provide a formal letter that acknowledges that there is a One Clean Up Program Agreement with Sunoco and it's currently operating under one EPA ID Number (PAD049791098) for Point Breeze, Girard Point and Schuylkill River Tank Farm;
- EPA will add in a Corrective Action Module to the Sunoco-submitted Draft Part B RCRA Permit. The module will reference the One Clean-Up Program agreement and the current remediation work being completed under the existing CO&A between PADEP and Sunoco, Inc.; and

- EPA will issue a letter to Sunoco for each characterized SWMU that lists a non-leaded tank bottom designation for which no further action is required.

Sunoco is also developing a report entitled, *Work Plan for Sitewide Approach Under the One Cleanup Program* (Work Plan for Sitewide Approach), to document the Sitewide remedial approach extending beyond the requirements of the 2003 CO&A. DEP and EPA have reviewed and provided input to this report and the final report is expected to be submitted to DEP and EPA in July 2011. In accordance with the Work Plan for Sitewide Approach, all SCRs that have been prepared under the 2003 CO&A will be repackaged as SCR/RIRs and re-submitted to allow for the reports submitted earlier under the CO&A process to be updated with current Act 2 standards and to satisfy the appropriate public and municipal notice provisions of Act 2. To date, SCR/RIRs have been prepared for AOIs 2, 3 and 7. This report is the fourth consecutive report to be submitted as an SCR/RIR.

2.0 ENVIRONMENTAL SETTING

AOI 10 is comprised of approximately 80 acres and is located west of the Schuylkill River and south of Passyunk Avenue (Figures 1 and 2). AOI 10 is mostly open space and bounded by Passyunk Avenue to the north-northwest, by the Schuylkill River to the east-southeast, and by industrial and open properties to the south and west. Lands Creek traverses the southern portion of AOI 10 (Figure 1).

2.1 Historic and Current Use

Historic Use

A detailed review of historical aerial photographs for AOI 10 is provided in Appendix B of the Work Plan. Based on a review of historical aerial photographs, several ASTs once existed in the northeastern and western portions of AOI 10 (Figure A-1 in Appendix A). Four PDAs exist in the topographically high areas of AOI 10 (Figure A-1 in Appendix A). PDAs 3 and 4 received primarily trash construction rubble, leaded tank bottom and separator sludges and spent catalyst during the 1950s. PDAs 1 and 2 received acid wastes, caustic waste, asphalt, coal slag, paraffin, bender catalyst and leaded sludge in the 1950s and 1960s. PDAs 1 and 2 were capped with clay materials and PDAs 3 and 4 were capped with clay and vegetative cover materials in the 1980s. The PDAs were

investigated as part of the 1992 RFI performed by ENSR. As part of the RFI activities, the PDAs were grouped into a CAMU. This CAMU is the only RCRA waste management unit in AOI 10. Other historic use areas in AOI 10 include a tankage area and associated pump houses in the northeast portion and two fuel docks along the eastern boundary with the river (Figure A-1 in Appendix A). The structures associated with the tanks and pump houses were demolished prior to 2005.

Currently, activities in the West Yard include maintenance of an existing Sunoco pipeline that is mostly above grade and extends along much of the northern AOI 10 boundary, and an aboveground manifold area that connects underground and aboveground lines between the refinery and Schuylkill River Tank Farm.

2.2 Geology

To further characterize geology at AOI 10, Sunoco advanced seven shallow and two intermediate monitoring wells. Shallow well borings were advanced into the fill/alluvium materials beneath AOI 10. Intermediate well borings were advanced into the Trenton Gravel beneath the fill/alluvium and above bedrock. Each shallow and intermediate boring was continually logged by a field geologist. The boring logs are provided in Appendix C. To illustrate the geology at AOI 10, two geologic cross sections were prepared and are provided as Figures 4a and 4b in this report. The cross section location lines are shown in plain view on these figures.

The following paragraphs describe the primary geologic units beneath AOI 10 beginning with the deepest unit to the shallowest unit:

Wissahickon Formation – Bedrock beneath the refinery and AOI 10 is identified as the Wissahickon Schist. This formation is a metamorphosed greenish-gray micaceous schist and quartzite. The competent bedrock of the Wissahickon Formation is overlain by weathered bedrock consisting of micaceous clay, which becomes increasingly sandy as the degree of weathering lessens and competent bedrock is encountered. Based on deep well and soil borings completed in AOI 10, the Wissahickon Schist ranges between approximately 30 and 80 feet beneath the ground surface. The bedrock elevation rises to the west. This range in bedrock depth is illustrated in Figures 4a and 4b.

Lower Sand Unit of the PRM – Throughout the majority of the Refinery, the Wissahickon Formation is overlain by the Lower Sand, which is the lowest member of the Potomac-Raritan Magothy (PRM) Aquifer System. Based on recent geologic data collected in AOI 10, the Lower Sand does not exist beneath AOI 10.

Middle/Lower Clay – The Middle/Lower Clay, where present beneath the refinery, is characterized by very low permeability reddish-brown, brown or gray clays and sandy clays. Based on recent geologic data collected in AOI 10, the Middle/Lower Clay does not exist beneath AOI 10. As shown in Figures 4a and 4b, some clay is present immediately above bedrock. The clay is absent in the western portions of AOI 10. As shown in Figures 4a and 4b, the clay, where present, ranges in thickness between approximately 2 feet to 5 feet.

Trenton Gravel – Throughout most of the refinery, the Trenton Gravel typically overlies the Middle/Lower Clay and Lower Sand with thicknesses up to 80 feet and a typical thickness of 40 feet. The Trenton Gravel is of Pleistocene Age (Ice Age; less than 2 million years) and is a very heterogeneous unit comprised of a predominant brown to gray sand, gravel and minor amounts of clay (Owens and Minard, 1979). As shown in Figures 4a and 4b, Trenton Gravel is present throughout AOI 10 above bedrock and beneath alluvium. The Trenton Gravel is approximately 10 feet thick in the western portion of AOI 10 and thickens to approximately 30 feet along the eastern portion of AOI 10.

Recent Fill/Alluvium - The alluvium deposits in AOI 10 generally consist of dark gray organic clayey mud or silt and fine sand. As shown in Figures 4a and 4b, alluvium deposits are approximately 50 to 65 feet thick in the eastern and northeastern portions of AOI 10 and thin to between 10 to 35 feet in the western and southern portions of AOI 10. As shown in Figures 4a and 4b, the alluvium thickens in the eastern portion of AOI 10 where the Pleistocene age deposits have been eroded and replaced. At these locations, the alluvium deposits are in direct contact with the Trenton Gravel.

Fill type varies across AOI 10 and includes various sands and gravels, brick and wood fragments, and cinder ash. Fill overlies the native alluvium throughout AOI 10 and ranges between 5 and 25 feet in thickness.

Based on the soil borings advanced through the CAMU areas, cover materials over the waste are present at thicknesses ranging between 2.5 and 12 feet. Waste materials in the CAMU areas range in thickness between 5 and 20 feet and lie on top of the alluvium (Figures 4a and 4b).

In addition to the above descriptions, the following general observations can be made concerning the geology in AOI 10:

- Fill materials are present throughout AOI 10;
- Alluvium is present beneath AOI 10 and thickens in a wedge shape towards the river;
- Trenton Gravel is present in all portions of AOI 10 beneath the alluvium and thins towards the river where the gravel has been eroded and replaced by the alluvium;
- The Middle/Lower Clay is absent in AOI 10; however, some clay is present immediately above bedrock in some locations;
- The Lower Sand is absent in AOI 10; and
- The depth to bedrock beneath AOI 10 increases towards the east. The shallowest depth to bedrock in the west is approximately 30 feet and the deepest depth to bedrock in the east is approximately 80 feet.

2.3 Hydrogeology

2.3.1 Shallow Groundwater Occurrence and Flow

Shallow groundwater in AOI 10 refers to unconfined groundwater that occurs in either the fill or alluvium (or both). Well construction details for these monitoring wells are provided in Table 2 and boring/well construction logs for the newly-installed wells are provided in Appendix C of this report. Groundwater gauging data collected by Stantec in April 2011 was used to generate a groundwater flow figure for the shallow zone in AOI 10 (Figure 5). The groundwater elevation data from this gauging event is provided in Table 3. Historic boring/well logs for wells installed prior to the site characterization activities are provided in Appendix D of the CCR.

Shallow groundwater flow within AOI 10 is described below:

- Groundwater in the shallow zone of AOI 10 occurs at depths ranging between 1 and 13 feet below the ground surface under unconfined conditions;
- Groundwater flow in the eastern portion of AOI 10 is to the east towards the Schuylkill River and groundwater flow in the western portion of AOI 10 is to the south;
- The hydraulic gradient in the western portion of AOI 10 is relatively flat (average gradient= 0.003 ft/ft) and steepens along the Schuylkill River (average gradient = 0.016 ft/ft);
- The vertical hydraulic gradient between the shallow and intermediate (Trenton Gravel) zones is downward at an average of 0.325 ft/ft.

2.3.2 Intermediate Groundwater Occurrence and Flow

Intermediate groundwater at AOI 10 refers to unconfined groundwater that occurs in Trenton Gravel situated beneath the alluvium. Six intermediate wells are located in AOI 10. These include: W-1D, W-9, W-13, W-19, W-26, and W-32D. Well construction details for these wells are provided in Table 2 and the available logs for these wells are provided in Appendix D of the CCR. Groundwater gauging data collected by Stantec in April of 2011 was used to generate a groundwater flow figure for the intermediate groundwater zone in AOI 10 (Figure 6). The groundwater elevation data from this gauging event is provided in Table 3.

Intermediate groundwater flow within AOI 10 is described below:

- Intermediate groundwater in AOI 10 occurs at depths ranging between 6 to 10 feet below the ground surface;
- Groundwater flow in the intermediate zone is towards the southwest under a low hydraulic gradient (average gradient = 0.0006 ft/ft); and
- The vertical hydraulic gradient between the shallow and intermediate (Trenton Gravel) zones is downward at an average of 0.325 ft/ft.

2.4 Surface Water

AOI 10 is mostly open space and bounded by Passyunk Avenue to the north-northwest, by the Schuylkill River to the east-southeast. Lands Creek traverses the southern portion of AOI 10 (Figure 1). As shown on Figure 1, Lands Creek is shown as a blue line stream. The surface water area of the creek is greater than 1,000 square feet and is not a permitted open water management area. The creek is a freshwater tidally influenced drainage feature which drains into the Schuylkill River. The creek is designated by PA as a warm water fishes stream. The confluence of Lands Creek and the Schuylkill River is in the southeast corner of AOI 10.

3.0 SITE CHARACTERIZATION ACTIVITIES

The following sections summarize the site characterization activities that were completed in AOI 10 in support of this SCR/RIR. Site characterization activities were performed between April and May 2011, by Aquaterra Technologies, Inc. (Aquaterra) and Langan in coordination with Sunoco. These activities were executed in accordance with the AOI 10 Work Plan for Site Characterization. In addition to the activities performed under the work plan, Stantec completed site characterization activities to address a vacuum gas oil (VGO) release in April 2010. All site characterization activities are discussed in the following sections.

3.1 Soil Borings and Sampling Outside of CAMU Areas

A total of 45 soil samples were collected for analysis of site COCs from areas within AOI 10 outside the CAMU. The locations of all soil and monitoring well borings are shown on Figure 3 and the boring logs are provided in Appendix C. Soil samples were collected utilizing macrocore sampling techniques. Soil borings outside the CAMU areas were advanced from depths ranging between 2 to 20 feet below grade using hollow-stem auger techniques in accordance with the Work Plan for Site Characterization.

Soil samples collected from these borings were submitted to Lancaster Laboratories, Inc. (LLI) of Lancaster, Pennsylvania for analysis of site COCs. A summary of the soil analytical results screened against the PADEP non-residential soil MSCs is provided in

Tables 4 and 5, and the results are discussed in Section 4.1. The laboratory analytical reports are provided as Appendix D.

3.2 Soil Borings and Sampling within CAMU Areas

A total of nine soil borings ranging in depths between 20 and 30 ft bgs were completed in the CAMU areas in accordance with the Work Plan. The purpose of these soil borings was to characterize the potential direct contact to shallow soil exposure pathway, characterize and delineate the waste material in the CAMU and characterize the soil beneath the waste in the CAMU. Soil borings were advanced utilizing hollow stem augers and macrocore sampling device. The locations of all soil and monitoring well borings are shown on Figure 3 and the boring logs are provided in Appendix C.

Soil samples were submitted to LLI of Lancaster, Pennsylvania for analysis of site COCs. A summary of the soil analytical results screened against the PADEP non-residential soil MSCs is provided as Tables 6, 7 and 8 and the results are discussed in Section 4.2. The laboratory analytical reports are provided as Appendix D.

3.3 Vacuum Gas Oil Release Cleanup

A release of VGO from a manifold area located in the northeastern portion of AOI 10 occurred in March 2010. The release was reported to be up to approximately 1,500 barrels of VGO. Remediation and post postremediation sampling programs were implemented by Sunoco. Sunoco directed the cleanup operations which included recovery of VGO by vacuum truck and excavation and disposal of impacted soils. Stantec performed post-excavation confirmatory soil sampling. Post-excavation soil samples were analyzed for site COCs as listed in the CCR. Locations of the post-excavation soil samples are illustrated on Figure 9 and the results of the sampling are discussed in Section 4.3. The laboratory analytical report for the samples is included in Appendix D.

3.4 Installation of Groundwater Monitoring Wells

Well installation activities were performed in April 2011 by Parrat Wolff, Inc. (PWI) of East Syracuse, New York under direct supervision of Aquaterra and Langan, and in coordination with Sunoco. The locations of all monitoring wells installed are shown on

Figure 3. Monitoring wells were installed to monitor the water table aquifers beneath AOI 10. The well installation activities are discussed in the following sections.

3.4.1 Shallow Groundwater Monitoring Wells

PWI installed seven shallow monitoring wells (fill/alluvium) under the direct supervision of Aquaterra and Langan. All wells were installed and constructed in accordance with the Work Plan. Locations of these wells are shown on Figure 3. Well borings were advanced utilizing 8.25-inch inside diameter hollow stem augers and macrocore samplers to record lithology. Monitoring wells were constructed to a maximum depth of 12 feet below grade with screen intervals between 2 and 12 feet, with the maximum screen length being 10 feet. Boring logs depicting monitoring well construction details and lithology are provided as Appendix C. Monitoring wells were constructed with a stickup steel casing for protection. Well construction details are provided in Table 2.

Following construction, the wells were developed in accordance with the Work Plan.

3.4.2 Intermediate Groundwater Monitoring Wells

Four intermediate groundwater monitoring wells previously existed in AOI 10. These wells include: W-9, W-13, W-19, and W-26. Two new intermediate wells (W-1D and W-32D) were installed as part of the site characterization activities. The locations of these intermediate monitoring wells are shown on Figure 3. Well construction details are provided in Table 2 and soil boring/well construction logs are provided in Appendix C. Geologic information obtained from the deep soil borings completed in AOI 10 was used to prepare geologic cross sections provided as Figures 4a and 4b.

3.5 Groundwater Monitoring

On April 27, 2011, Aquaterra performed monitoring well gauging activities to collect liquid levels from monitoring points within AOI 10. Monitoring points were gauged for depth-to-water, and if applicable, depth-to-product in accordance with the Work Plan. All monitoring point gauging readings are summarized in Table 3.

The groundwater monitoring data from Table 3 was used to generate shallow and intermediate groundwater elevation contours provided as Figures 5 and 6, respectively.

3.6 Groundwater Sampling

Aquaterra performed a round of groundwater sampling from all accessible wells in AOI 10 between April 26 and 27, 2011. All groundwater sampling activities were completed using three well volume purging techniques in accordance with the AOI 10 Work Plan. The monitoring well sampling summary data sheets are provided as Appendix E.

Following well purging activities, groundwater samples were collected by lowering a disposable bailer slowly into the monitoring well to minimize excess agitation. The bailer was filled with water from the top of the water table and retrieved. Samples were then collected in laboratory-prepared bottleware and immediately placed on ice. Samples were submitted to LLI for analysis of site COCs listed in Table 1b. Once the sample was collected, the bailer, bailer cord, and nitrile gloves used to obtain the sample were discarded. Sample date, time, number, and site name were recorded on the chain-of-custody and in field books. For groundwater samples analyzed for lead, LLI filtered the samples to analyze for dissolved concentrations.

The groundwater analytical results for shallow wells were screened against the PADEP non-residential groundwater MSCs and are presented in Table 9. The groundwater analytical results for the intermediate wells are presented in Table 10. The laboratory analytical reports are included as Appendix D.

3.7 Surface Water and Sediment Sampling

On April 7, 2011, Aquaterra and Langan performed surface water and sediment sampling activities at Lands Creek. Sediment and surface water samples were collected from five locations. These sample locations are shown on Figure 3. All samples were collected in accordance with the Work Plan.

Surface water and sediment samples were submitted to LLI of Lancaster, Pennsylvania for analysis of COCs as listed in Table 1c and 1d, respectively. A summary of the analytical results screened against the appropriate screening criteria is provided as

Tables 11 and 12 and the results are discussed in Section 4.5. The laboratory analytical reports are provided as Appendix D.

3.8 LNAPL Sampling

Light non-aqueous phase liquid (LNAPL) samples for select wells in AOI 10 were previously characterized as described in the CCR. As part of the site characterization activities, Aquaterra collected LNAPL samples from three existing monitoring wells in AOI 10 to further characterize LNAPL in AOI 10. The wells included W-8, W-14, and W-18. LNAPL samples were collected using a direct sampling method in accordance with the Work Plan. LNAPL samples were packaged in certified hazardous material shipping boxes and shipped to Torkelson Laboratories (Torkelson) of Tulsa, Oklahoma for LNAPL characterization. LNAPL characterization data included product types, density, proportions of product, degree of weathering, and similarities to other LNAPL samples collected at the Refinery.

Appendix F summarizes the LNAPL characterization results for all samples collected in AOI 10 as well as previous results from the CCR.

3.9 Surveying Activities

Following completion of well installation and soil boring activities, the newly-installed monitoring wells and soil boring locations were surveyed by Langan to establish the location and elevation of the inner and outer casing and ground surface at each point. All well elevations were determined to the nearest 0.01 foot relative to mean sea level. All survey activities were performed by a Pennsylvania-licensed surveyor and tied to the NAVD 88 datum. The new survey data for the monitoring wells is presented in Table 2. This new survey data was used to update the Geographic Information System (GIS) and site wide database for the Refinery.

4.0 SITE CHARACTERIZATION ANALYTICAL RESULTS

The following sections discuss the results of the site characterization activities performed in AOI 10.

4.1 Soil Analytical Results for Samples Collected Outside of CAMU Areas

The results of the soil samples collected outside of the CAMU areas are provided in Tables 4 and 5. Table 4 includes soil sample results from samples that were collected from shallow borings outside the CAMU areas. These soil samples were analyzed for the site COCs only (Table 1b). Table 5 includes shallow soil sample results from samples collected around the perimeter of the CAMU areas (horizontal delineation borings). These soil samples were analyzed for TCL VOC, SVOC and TAL Metals lists, which are broader than the site COC list. All of the soil samples were collected between zero to two feet below grade and no saturated soils were observed in this interval. The soil sample results were screened against the PADEP non-residential soil MSCs for unsaturated soils. Soil samples with results above their respective soil MSCs are shown in Figure 7.

Below is a general summary of the screening results:

- COCs detected in soil above their respective non-residential soil MSCs included: benzene, benzo(a)pyrene, PCE, arsenic, manganese, and lead; and
- All other COCs analyzed in Tables 4 and 5 were below their respective non-residential soil MSCs.

4.2 Soil Results within CAMU Areas

The results of the samples collected inside the CAMU are provided in Tables 6, 7 and 8. Table 6 includes results from soil samples that were collected from 0 and 2 feet below the ground surface above the waste. Table 7 includes results from waste samples collected from the waste inside the CAMU areas (cover materials). Table 8 includes results from soil samples collected beneath the waste inside the CAMU areas (vertical delineation borings). These soil samples were analyzed for TCL VOC, SVOC and TAL Metals lists, which is an expanded list from the site COC list. The soil sample results were screened against the PADEP non-residential soil MSCs. Soil samples with results above their respective soil MSCs are shown in Figure 8. Below is a summary by depth interval of the screening results:

Shallow Soil Samples:

- COCs detected in shallow soil above their respective non-residential soil MSCs included: benzo(a)pyrene, dibenzo(a,h)anthracene, manganese and lead.
- All other COCs were below their respective non-residential soil MSCs.

Waste Samples:

- COCs detected in waste samples above the non-residential soil MSCs included: benzene, methylene chloride, PCE, ethylbenzene, toluene, 1,2-DCE, 2-methylnaphthalene, benzo(a)pyrene, naphthalene, dibenzofuran, antimony, arsenic, barium, cobalt, lead, manganese, mercury, nickel, thallium, and zinc.
- All other COCs analyzed were below their respective non-residential soil MSCs.

Vertical Delineation Soil Samples:

- COCs detected in the vertical delineation soil samples (collected beneath the waste) above the non-residential soil MSCs included: benzene, benzo(a)pyrene, naphthalene, arsenic, barium, cobalt, lead, manganese, mercury, nickel, and thallium.
- All other COCs analyzed were below their respective non-residential soil MSCs.

4.3 Vacuum Gas Oil Release Area - Post Excavation Soil Sample Results

Stantec collected a total of 10 unsaturated, post-excavation soil samples following the excavation of VGO-impacted soil. The locations of the soil samples are shown in Figure 9. The samples were analyzed for site COCs as listed in the CCR. The results of the soil samples are screened against the DEP non-residential soil MSCs in Table 9. All soil samples analyzed for site COCs were below their respective non-residential soil MSCs.

4.4 Groundwater Results

The results of the groundwater samples collected from shallow and intermediate monitoring wells are provided in Tables 10 and 11, respectively. The results were screened against the PADEP non-residential used aquifer (TDS<2,500) groundwater MSCs. Locations with concentrations above the groundwater MSCs are illustrated in

Figure 10. A summary of the COC concentrations observed in both the shallow and intermediate wells is provided below.

Shallow Wells

- COCs at concentrations above their respective non-residential groundwater MSCs included: benzene, chrysene, naphthalene, and lead.
- All other COCs analyzed in Table 10 were below their respective non-residential groundwater MSCs.

Intermediate Wells

- There were no COCs detected in intermediate wells above their respective non-residential groundwater MSCs.

4.5 Surface Water and Sediment Results

Surface Water

The locations of the five surface water samples collected from Lands Creek are shown in Figure 3. The samples were submitted for analysis of COCs listed in Table 1c. The results of the samples were screened against the 25 Pa. Code, Chapter 93 Fish and Aquatic Life criteria in Table 12. To calculate the criteria for constituents that require hardness data, site-specific hardness data collected at each sampling location was used. Total and dissolved surface water samples were analyzed.

Based on the results of the screening, no COCs (both total and dissolved) were detected in the surface water samples at concentrations above their respective Chapter 93 screening criteria.

Sediment

The locations of the five sediment samples collected from Lands Creek are shown in Figure 3. The sediment samples were collected at the same locations as the surface water samples and were submitted for analysis of COCs listed in Table 1d. Results of the samples were screened against the EPA Region 3 Biological Technical Assistance Group (BTAG) sediment and surface water benchmarks and the LEL and SEL in Table 13. Sample locations exhibiting COC concentrations above these sediment screening criteria are depicted on Figure 11. Total organic carbon data was collected at

each sample location and was used to calculate site-specific SEL criteria where required.

Based on the results of the screening, no volatile organic constituents exceeded the sediment screening criteria. Below is a summary of the semi-volatile organic constituents and metal results that were above the sediment screening criteria:

- COCs which were detected above the SEL included: anthracene, benzo(ghi)perylene, chysene, phenanthrene, pyrene, arsenic, chromium (total), copper, iron, lead, manganese, mercury, nickel, and zinc.

4.6 LNAPL Characterization Results

During the April 2011 gauging event, three monitoring wells in AOI-10 (W-8, W-14, and W-18) had measurable LNAPL ranging in thickness between 0.01 and 0.59 ft. As part of the site characterization activities, LNAPL samples were collected from each of the three wells and submitted to Torkelson Geochemistry, Inc. of Tulsa, Oklahoma for characterization. Appendix F summarizes the LNAPL characterization results from the CCR and the recent site characterization activities and also includes the laboratory data reports for the sampled wells. Based on the LNAPL characterization performed by Torkelson, the LNAPL types present in AOI 10 include extremely weathered residual oil in W-8 and extremely weathered residual oil/middle distillate in monitoring wells W-14 and W-18.

LNAPL modeling, using the API model was completed as part of the 2004 CCR to evaluate specific volume and LNAPL mobility for product in some of these wells. The LNAPL type, absence of LNAPL in the surrounding monitoring wells, groundwater flow direction, and the LNAPL modeling performed as part of the CCR, all suggest LNAPL in these wells is stable and immobile. Therefore, no additional LNAPL modeling was completed as part of this SCR/RIR.

LNAPL occurrence in AOI 10 is illustrated in Figure 12.

5.0 REMEDIAL SYSTEMS

There are no active remediation systems currently operating in AOI 10.

6.0 FATE AND TRANSPORT ANALYSIS

The following sections describe fate and transport modeling activities performed as part of AOI 10 site characterization.

6.1 Soil

No fate and transport modeling was completed for the soil analytical results since the only potential exposure pathway to soil is by direct contact to shallow soil. The soil-to-groundwater pathway is evaluated through groundwater data. Potential exposure pathways for AOI 10 are discussed in more detail in Section 8.0.

6.2 Groundwater

Fate and transport modeling was completed for eight wells in AOI 10 (W-1, W-12, W-23, W-28, W-31, W-32, W-33, and W-34) that exhibited concentrations of COCs above their respective PADEP non-residential groundwater MSCs. The modeling was performed to evaluate whether concentrations of COCs in groundwater, above MSCs, have the potential to reach the AOI boundary or Lands Creek.

Fate and transport modeling was performed using the Quick Domenico (QD) model. The QD Version 2 spreadsheet model and either PADEP default or site-specific data were used to perform the fate and transport calculations. A more detailed description of QD model input parameters and results are presented in Appendix G. Input and result summary spreadsheets for each monitoring well modeled are included in Appendix G (Tables G.1 through G.9). The results of the QD screening are located in Table G.5. A comparison between the model-predicted downgradient transport distance and the distance to the nearest property boundary and/or surface water receptor is also included in these tables.

The modeling results indicate concentrations above the groundwater MSCs in shallow wells W-1, W-12, W-23, W-28, W-31, W-32, and W-34 are not predicted to migrate beyond the AOI 10 boundary, with the exception of one well, W-33, which contains a concentration of benzene that has the potential to reach Lands Creek. However, the

predicted benzene concentration at the Lands Creek boundary is below the 25 Pa. Code Chapter 93 surface water quality criteria for benzene.

6.3 Surface Water

Based on the results of the QD simulations, groundwater concentrations above the MSCs are not expected to reach the Schuylkill River. In addition, surface water samples collected from Lands Creek exhibited no COC concentrations above the 25 Pa. Code Chapter 93 screening criteria.

6.4 LNAPL

Wells W-8, W-14, and W-18 were the only wells in AOI 10 that contained measurable LNAPL. Based on the LNAPL type and mobility, degree of severe LNAPL weathering, absence of LNAPL in the surrounding monitoring wells, groundwater flow/gradients, and the LNAPL mobility modeling performed as part of the CCR, LNAPL in these wells is considered to be stable and immobile. Therefore, no additional LNAPL modeling was completed as part of this SCR/RIR.

6.5 Vapor Intrusion into Indoor Air

Currently there are no occupied buildings in AOI 10. Therefore, there are no potential receptors to vapor intrusion (VI) into indoor air within AOI 10. Soil and groundwater samples collected in AOI 10 were evaluated in accordance with the current Act 2 Vapor Intrusion Guidance, where applicable. The groundwater table is less than five feet below the ground surface in several areas of AOI 10. Groundwater and soil samples collected in these areas were not screened against the default screening numbers in the guidance. In addition, the waste in the CAMU areas is not considered soil-like; therefore, analytical data from the waste samples was not screened. The refinery is regulated under OSHA; therefore, the appropriate OSHA standard was applied when evaluating the potential indoor air pathway. The screening evaluation using applicable soil and groundwater data indicated that no soil or groundwater analytical results in AOI 10 are above the non-residential EPA/PADEP default screening values or the OSHA PEL screening values.

No soil gas sampling was completed as part of this site characterization, but if future development is proposed for the areas that were not able to be screened using the PADEP vapor screening criteria, soil gas sampling would be completed in these areas.

7.0 SITE CONCEPTUAL MODEL

A preliminary site conceptual model (SCM) for the Refinery, including AOI 10, was presented in the CCR. Data collected from the recent site characterization activities performed in AOI 10 were used to refine the SCM for this area. The revised SCM for AOI 10 is described in the following sections:

7.1 Description and Site Use

The current and future intended use of AOI 10 is non-residential. AOI 10 is located west of the Schuylkill River across from the northern portion of the South Yard. It is bordered by Passyunk Avenue to the North, the Schuylkill River to the Southeast and other industrial properties to the southwest. Lands Creek traverses the southern portion of AOI 10.

Based on a review of historical aerial photographs, several ASTs once existed in the northeastern and western portions of AOI 10 (Figure A-1 in Appendix A). Four PDAs exist in the topographically high areas of AOI 10 (Figure A-1 in Appendix A). PDAs 3 and 4 received primarily trash construction rubble, leaded tank bottom and separator sludges and spent catalyst during the 1950s. PDAs 1 and 2 received acid wastes, caustic waste, asphalt, coal slag, paraffin, bender catalyst and leaded sludge in the 1950s and 1960s. PDAs 1 and 2 were capped with clay materials and PDAs 3 and 4 were capped with clay and vegetative cover materials in the 1980s. Other historic use areas in AOI 10 include a tankage area and associated pump houses in the northeast portion and two fuel docks along the eastern boundary with the river (Figure A-1 in Appendix A). The structures associated with the tanks and pump houses were demolished prior to 2005.

Currently, activities in the West Yard include maintenance of an existing Sunoco pipeline that is mostly above grade. The pipeline extends along much of the northern AOI 10

boundary and an aboveground manifold area that connects underground and aboveground lines between the refinery and Schuylkill River Tank Farm.

AOI 10 is located within a fenced and secured area to prevent unauthorized access. Prior to any work being completed within AOI 10, appropriate work permits, safety and security measures must be approved by Sunoco Refinery personnel. AOI 10 is under the control of Sunoco's health and safety administrative procedures and is regulated by OSHA. Direct contact to site soils (soils greater than two feet beneath the ground surface) is controlled by Sunoco's on-site permit and personal protective equipment (PPE) procedures.

7.2 Geology and Hydrogeology

The following summarizes relevant information concerning geology and hydrogeology in AOI 10:

Geology

- Fill materials are present throughout AOI 10;
- Waste materials in the PDAs range in thickness between 5 and 20 feet thick;
- Alluvium is present beneath AOI 10 and thickens in a wedge shape towards the river;
- Trenton Gravel is present in all portions of AOI 10 beneath the alluvium and thins towards the river where the gravel has been eroded and replaced by the alluvium;
- The Middle/Lower Clay is absent in AOI 10; however, some clay is present immediately above bedrock in some locations;
- The Lower Sand is absent in AOI 10; and
- The depth to bedrock beneath AOI 10 increases towards the east. The shallowest depth to bedrock in the west is approximately 30 feet and the deepest depth to bedrock in the east is approximately 80 feet.

Hydrogeology

- Groundwater in the shallow zone of AOI 10 occurs at depths ranging between 1 and 13 feet below the ground surface under unconfined conditions;

- Groundwater flow in the eastern portion of AOI 10 is to the east towards the Schuylkill River and groundwater flow in the western portion of AOI 10 is to the south;
- The hydraulic gradient in the western portion of AOI 10 is relatively flat (average = 0.003 ft/ft) and steepens along the Schuylkill River (average gradient = 0.016 ft/ft);
- Intermediate groundwater in AOI 10 occurs at depths ranging between 6 to 10 feet below the ground surface;
- Groundwater flow in the intermediate zone is towards the southwest under a low hydraulic gradient (average gradient = 0.0006 ft/ft); and
- The vertical hydraulic gradient between the shallow and intermediate (Trenton Gravel) zones is downward at an average of 0.325 ft/ft.

7.3 Constituents of Concern

The following summarizes relevant information concerning COCs in AOI 10:

Soil Samples Collected Outside of CAMU Areas

Shallow soil samples were collected outside the CAMU areas and deeper soil samples were collected around the perimeter of the CAMU areas to horizontally delineate the extent of the waste in the CAMUs. In addition, post-excavation soil samples were collected from the area of the VGO release. The results of these soil samples are summarized below:

- COCs detected in soil above their respective non-residential soil MSCs included: benzene, benzo(a)pyrene, PCE, arsenic, manganese, and lead; and
- All other COCs were below their respective non-residential soil MSCs, including all of the post-excavation samples.

Soil Samples Collected Inside CAMU Areas

Soil samples were collected from three depth intervals inside the CAMU areas. These intervals correspond to soil materials above the waste, waste and soil materials beneath the waste. The results of the soil samples are summarized below by corresponding depth interval:

Shallow Soil Samples:

- COCs detected in shallow soil above their respective non-residential soil MSCs included: benzo(a)pyrene, dibenzo(a,h)anthracene, manganese and lead.
- All other COCs were below their respective non-residential soil MSCs.

Waste Samples:

- COCs detected in waste samples above the non-residential soil MSCs included: benzene, methylene chloride, PCE, ethylbenzene, toluene, 1,2-DCE, 2-methylnaphthalene, benzo(a)pyrene, naphthalene, dibenzofuran, antimony, arsenic, barium, cobalt, lead, manganese, mercury, nickel, thallium, and zinc.
- All other COCs analyzed were below their respective non-residential soil MSCs.

Vertical Delineation Soil Samples:

- COCs detected in the vertical delineation soil samples (collected beneath the waste) above the non-residential soil MSCs included: benzene, benzo(a)pyrene, naphthalene, arsenic, barium, cobalt, lead, manganese, mercury, nickel, and thallium.
- All other COCs analyzed were below their respective non-residential soil MSCs.

Groundwater

Groundwater samples were collected from all wells that did not contain LNAPL. This included wells that screen both the shallow and intermediate zones. The results of the groundwater samples are summarized below by corresponding hydrogeologic zone:

Shallow Wells

- COCs at concentrations above their respective non-residential groundwater MSCs included: benzene, chrysene, naphthalene, and lead.
- All other COCs were below their respective non-residential groundwater MSCs.

Intermediate Wells

- There were no COCs detected in intermediate wells above their respective non-residential groundwater MSCs.

The exposure assessment completed for the COCs above the MSCs is discussed in Section 8.0 of this report.

Surface Water

Five surface water samples were collected from Lands Creek. None of the samples exhibited concentrations of COCs above their respective 25 Pa. Code Chapter 93 screening criteria.

Sediment

Five sediment samples were collected from Lands Creek at locations corresponding to the surface water samples. The results of the sediment samples are summarized below:

- No VOC concentrations were above the sediment screening criteria.
- SVOCs and metals detected above the SEL included: anthracene, benzo(ghi)perylene, chysene, phenanthrene, pyrene, arsenic, chromium (total), copper, iron, lead, manganese, mercury, nickel, and zinc.

7.4 LNAPL Distribution and Mobility

The following summarizes relevant information concerning LNAPL distribution in AOI 10:

- W-8, W-14, and W-18 contained measurable LNAPL and the product type is identified as extremely weathered residual oil and/or residual oil/middle distillate.
- The occurrence of LNAPL does not correlate with the COC concentrations which were above MSCs in shallow groundwater in these areas.
- Based on LNAPL modeling performed for the CCR, the LNAPL type, degree of weathering, groundwater flow/gradients, the absence of LNAPL in the surrounding monitoring wells, and the occurrence of LNAPL in these wells over time, LNAPL in these wells is considered to be stable and immobile.

7.5 Fate and Transport of COCs

- No fate and transport modeling was completed for the soil analytical results since the only potential exposure pathway to soil is by direct contact. The soil-

to-groundwater pathway is evaluated through groundwater data.

- Fate and transport calculations were completed for groundwater in AOI 10 to evaluate potential migration pathways/potential impacts to receptors. Eight wells (W-1, W-12, W-23, W-28, W-31, W-32, W-33, and W-34) in AOI 10 exhibited concentrations of groundwater COCs above their respective MSCs. The results from these wells were modeled using the QD model to determine whether COC concentrations could potentially reach the AOI 10 boundary. The modeling results indicate concentrations above the groundwater MSCs in shallow wells W-1, W-12, W-23, W-28, W-31, W-32, and W-34 are not predicted to migrate beyond the AOI 10 boundary, with the exception of one well, W-33, which contains a concentration of benzene that has the potential to reach Lands Creek. However, the predicted benzene concentration at the Lands Creek boundary is below the 25 Pa. Code Chapter 93 surface water quality criteria for benzene.

7.6 Potential Migration Pathways and Site Receptors

The following summarizes potential migration pathways and site receptors for AOI 10.

- AOI 10 is situated within a fenced, secured area to prevent unauthorized access. The potential direct contact pathway to soil greater than two feet is deemed incomplete based on Sunoco's existing permitting procedures which protect against exposure to soil encountered in excavations.
- There are no occupied buildings in AOI 10. The potential direct contact pathway to groundwater is deemed incomplete based on Sunoco's existing permitting procedures which prevent exposure to groundwater that may be encountered in excavations.
- Dissolved COCs in groundwater are not predicted to migrate beyond the AOI 10 boundary or trigger a condition in surface water that would exceed a water quality standard.
- COC concentrations above the ecological screening limits in sediment collected from Lands Creek are discussed in more detail Section 9.0.
- Lands Creek is surrounded by fencing and is within the limits of AOI 10. This fencing, in conjunction with Sunoco's permitting procedures which protect

against exposure during activities in the creek, eliminates the human health direct contact pathway to the creek sediments.

- The vapor intrusion screening evaluation using applicable soil and groundwater data indicated that no soil or groundwater analytical results in AOI 10 are above the non-residential EPA/PADEP default screening values or the OSHA PEL screening values;
- No soil gas sampling was completed as part of this site characterization, but if future development is proposed for the areas that were not able to be screened using the PADEP vapor screening criteria, soil gas sampling would be completed in these areas.

8.0 HUMAN HEALTH EXPOSURE ASSESSMENT/RISK ASSESSMENT

Based on the current and future intended non-residential site use for AOI 10, an exposure assessment was conducted for all constituents that were above the non-residential statewide health standards in AOI 10. Potential human health exposures for the Refinery are for an industrial worker scenario. The media evaluated included groundwater, surface soil (less than two feet below grade), and subsurface soil (greater than two feet below grade). As described in Section 6.5, further evaluation of the vapor intrusion pathway is not required based on the lack of receptors and complete exposure pathways.

The potential direct contact pathway for soil (greater than two feet), groundwater and LNAPL under the industrial scenario is eliminated through Sunoco's established excavation procedures, PPE requirements and soil handling procedures described in Appendix K of the CCR. However, because direct contact to surface soils could occur outside of excavation activities, shallow soil samples were collected in non-paved areas of AOI 10 to assess this potential exposure pathway.

The following table serves as a summary of potential human health exposure pathways that can be reasonably expected under the current and intended future non-residential use for AOI 10. The table lists potentially contaminated media, potential receptors for these media, and a summary of whether any potentially-complete exposure pathways exist at AOI 10 from the media to these receptors.

Exposure Pathway Evaluation Summary

Contaminated Media	Residents	Workers	Day Care	Construction	Trespassers	Recreation	Food
Groundwater	NA	No(1)	NA	No(2)	No	NA	NA
Air (indoor)	NA	No(3)	NA	No(3)	No	NA	NA
Soil <2 feet bgs.	NA	Yes	NA	Yes	No	NA	NA
Soil >2 feet bgs.	NA	No(4)	NA	No(4)	No	NA	NA
Surface Water	NA	No(5)	NA	No(5)	NA	NA	NA
Sediment	No	No(5)	NA	No(5)	NA	NA	NA
LNAPL	NA	No(1)	NA	No(2)	NA	NA	NA

Notes:

(1) No complete groundwater or LNAPL pathways exist for workers that are not addressed through on-site permitting procedures and PPE.
(2) No complete groundwater or LNAPL pathway exists for construction workers that are not addressed through on-site permitting procedures and PPE.
(3) No complete pathway to indoor air exists based on the evaluation described in Section 6.5.
(4) No complete pathway exists for site soil >2 feet deep that are not addressed through on-site permitting procedures and PPE.
(5) No complete pathway exists for surface water or sediment that are not addressed through on-site permitting procedures and PPE.

Na - Not applicable
No - No potential complete exposure pathway
Yes – Potential complete exposure pathway

A more detailed evaluation of each of these potential human health exposure pathways is presented in the following sections by media.

8.1 Surface Water/Sediment

Lands Creek is as surface water body located in AOI 10. Lands Creek is located within a fenced and secured area to prevent unauthorized access. Prior to any work being completed within AOI 10, appropriate work permits, safety and security measures must be approved by Sunoco Refinery personnel. These procedures protect against any potential exposures to surface water or sediments in Lands Creek.

8.2 Shallow Soils (0-2 Feet Below Grade)

8.2.1 Direct Contact Exposure

In AOI 10, shallow soil samples were collected from within the CAMU and around the perimeter of the CAMU. To determine if any risk to the industrial worker exists due to direct contact, these samples were compared to the non-residential direct contact medium specific concentrations [PA Code Title 25, Chapter 250.305, Appendix A, Tables 3A and 4A]. Within the CAMU designated area, concentrations of benzo(a)pyrene and dibenzo(a,h)anthracene were

detected above their respective direct contact MSCs. Outside the CAMU designated area, concentrations of arsenic, benzo(a)pyrene, and lead were detected above their respective direct contact MSCs. In accordance with Section IV of the PADEP's Technical Guidance Manual, site-specific standards for the above-mentioned constituents were calculated using PADEP default intake parameters for an onsite worker and a risk level of 10^{-4} (Tables H-1 through H-5 in Appendix H). For calculating a site-specific standard for on-site workers exposed to lead, Sunoco used the Society of Environmental Geochemistry and Health (SEGH) model used by PADEP to develop the non-residential soil MSCs.

The calculated site-specific standards are summarized in the table below:

Compound	**Calculated Site-Specific Standard (mg/kg)**
Arsenic [non-carcinogenic / carcinogenic]	8,520/529*****
Benzo(a)pyrene	109
Dibenzo(a,h)anthracene	109
Lead	1,708

***Note:** Arsenic has both carcinogenic and non-carcinogenic toxicological effects; therefore, both criteria were calculated. For characterization, the lower, more stringent standard was used to screen the analytical data.*

The site-specific screening levels for arsenic, benzo(a)pyrene, and dibenzo(a,h)anthracene were calculated for ingestion based on the calculations specified in 25 Pa. Code § 250.306(b). These calculations used the PADEP's default parameters and an updated target risk level of 1E-4, in consideration of the site-specific conditions (PADEP's default target risk level is 1E-5).

The site-specific screening level for lead was also calculated for ingestion. As presented in 25 Pa. Code § 250.306(e), Appendix A, Table 7, the non-residential soil screening value for lead is based on the method presented in the report 'The Society for Environmental Geochemistry and Health (SEGH) Task Force Approach to the Assessment of Lead in Soil' (Wixson, 1991). The model used by the PADEP and developed by SEGH was also used to calculate the site-specific criterion for the refinery. Based on the SEGH model and PADEP's default parameters, PADEP's non-residential direct contact MSC default value

for lead in surface soil is 1,000 mg/kg. To develop a site-specific criteria for lead, some of the parameters used by the PADEP were updated in consideration of site-specific conditions and updated lead data collected from recent studies. As presented in Appendix H, based on the revised parameters, the derived site-specific standard for lead in soil is 1,708 mg/kg for a refinery worker.

Shallow soil sample results for arsenic, benzo(a)pyrene, dibenzo(a,h)anthracene and lead were compared to the calculated site-specific standards. None of the reported results for arsenic or dibenzo(a,h)anthracene were detected above the site-specific standards; however, the results for benzo(a)pyrene and lead were detected above the site-specific standard in seven samples (one sample for benzo(a)pyrene and six samples for lead). In addition to comparing the individual results to the site-specific standards, the cumulative risk of exposure to arsenic, benzo(a)pyrene, and dibenzo(a,h)anthracene in shallow soil throughout AOI 10 was also calculated (Table H-6). Based on the PADEP's TGM, the total cumulative risk for exposure to carcinogenic compounds should not exceed 1E-4 and the cumulative hazard index for exposure to non-carcinogenic compounds should not exceed 1. Lead exposure is dependent on the blood/lead concentration and not risk based; therefore, lead could not be incorporated into the cumulative risk calculation.

As presented in Table H-6:

- The total cumulative hazard index for exposure to the non-carcinogenic compound [arsenic] is less than the PADEP's requirement of 1.0; and
- The total cumulative risk for exposure to carcinogens is 3.65E-04, greater than the acceptable risk of 1.0E-04.

8.3 Groundwater

Results of the groundwater sampling indicated COCs at concentrations above their respective non-residential groundwater MSCs, including benzene, chrysene, naphthalene, and lead. Concentrations of these COCs are not predicted to migrate beyond the boundaries of AOI 10 or trigger a condition in surface water that would exceed a water quality standard.

Excavations in AOI 10 are governed by Sunoco's permitting procedures which protect against potential exposures to groundwater that could be encountered in an excavation. Previous investigations and well searches verified that no monitoring wells located within 1.5 miles of the refinery are used for drinking water or agricultural use.

8.4 LNAPL

There are no complete direct contact exposure pathways for LNAPL within AOI 10 because of on-site permitting procedures and required PPE.

8.5 Vapor

There are no buildings in AOI 10. The results of the screening evaluation using the PADEP's vapor intrusion guidance indicate, in the areas where the guidance can be applied, no soil or groundwater analytical results exceed the non-residential EPA/PADEP OSHA PEL screening values. No soil gas sampling was completed as part of this site characterization, but if future development is proposed for the areas that were not able to be screened using the PADEP vapor screening criteria, soil gas sampling would be completed in these areas.

9.0 ECOLOGICAL ASSESSMENT

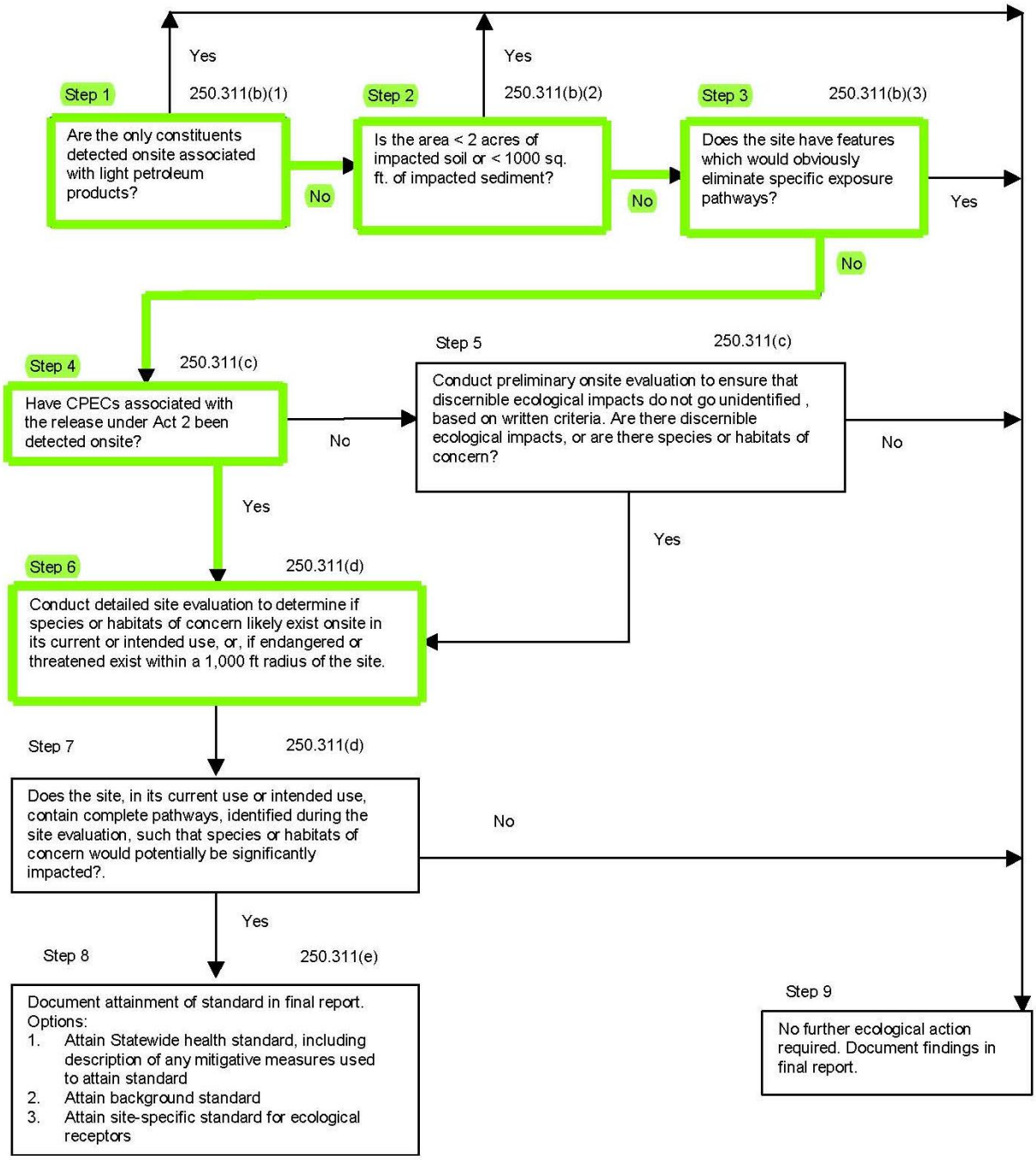
The majority of AOI 10 is covered with soil and gravel. The soil and gravel-covered portions of AOI 10 are not likely to serve as a breeding area, migratory stopover, or primary habitat for wildlife. An inquiry to identify potential endangered, threatened and special concern wildlife was made by submitting a request to the Pennsylvania Natural Diversity Inventory (PNDI) data base. The PNDI search identified two potential impacts that require further review. The first potential impact was for an endangered species identified by the PA Game Commission as the Great Egret. The second is a potential conflict of an unidentified threatened species listed by the PA Fish and Boat Commission.

Lands Creek is a surface water body located within AOI 10 and is identified as a blue line stream on the USGS topographic map (Figure 1). The creek is designated a warm water fishes stream by PA. A fence is located around the perimeter of the creek preventing access to the creek from outside the Sunoco property. A Langan representative completed an on-site

evaluation of the creek area in April 2011 and identified true sediment exists within the creek. No stressed vegetation was observed. The surface water area of the creek is greater than 1,000 square feet and is not a permitted open water management area. The creek is a freshwater, tidally-influenced drainage feature that is separated from the Schuylkill River by an earthen mound.

Five surface water samples were collected from Lands Creek and analyzed for COCs listed in Table 1c. The results indicate that no COCs were above the 25 Pa. Code Chapter 93 screening criteria for ecological receptors. Five sediment samples were also collected and analyzed for COCs listed in Table 1d. The results of the samples are discussed in Section 4.5.

To further evaluate the ecological conditions relating to Lands Creek, an ecological screening assessment was performed in accordance with Act 2 Technical Guidance Manual (TGM). On the following page is the ecological screening flow chart from the TGM. The AOI-10 decision path is highlighted in green.



Based on the ecological screening evaluation, additional work needs to be completed to determine if the threatened and endangered species listed in PNDI receipt, or suitable habitat for these species, exist within a 1,000 foot radius of the site.

10.0 COMMUNITY RELATION ACTIVITIES

A Community Relation Plan (CRP) that includes public involvement with local residents to inform them of the anticipated investigations and remediation activities was completed as part of the NIR submittal in 2006. The purpose of this CRP is to provide a mechanism for the community, government officials, and other interested or affected citizens to be informed of on-site activities related to the investigation activities at the Site. This plan incorporates aspects of public involvement under both PADEP's Act 2 program and EPA's RCRA Corrective Action program. This report and future Act 2 reports will include the appropriate municipal and public notices in accordance with the provisions of Act 2. Notices will be published in the Pennsylvania Bulletin and a summary of the notice will appear in a local newspaper. As part of the CRP, Sunoco intends to hold annual public meetings in the City of Philadelphia give status updates of the project.

EPA will complete its own public involvement through notices under the Corrective Action Program and by updating its online Fact Sheet for the refinery. A copy of the NIR and the Act 2 report notifications for this SCR/RIR are included in Appendix B.

11.0 CONCLUSIONS AND RECOMMENDATIONS

Based on the results of the completed activities, the following conclusions and recommendations have been developed for AOI 10:

SOIL

Shallow Soil

- Shallow soil sample results for arsenic, benzo(a)pyrene, dibenzo(a,h)anthracene and lead were compared to the calculated site-specific standards. None of the reported results for arsenic or dibenzo(a,h)anthracene were detected above the site-specific standards.
- A concentration of benzo(a)pyrene was detected above the site-specific standard in one sample location (BH-10-64). Sunoco will delineate the area where benzo(a)pyrene exceeds the calculated site-specific standard at BH-10-64. Following delineation, Sunoco will consider remedial options to address this area. Remedial options will be presented in the Cleanup Plan for AOI 10.

- Concentrations of lead were detected above its calculated site-specific standard at six sample locations (BH-10-51, BH-10-53, BH-10-57, BH-10-62, BH-10-73, and BH-10-76). Sunoco will delineate the areas where lead exceeds the calculated site-specific standard. Following delineation, Sunoco will consider remedial options to address these areas. Remedial options will be presented in the Cleanup Plan for AOI 10.
- The total cumulative hazard index for exposure to the non-carcinogenic compound [arsenic] is less than the PADEP's requirement of 1.0.
- The total cumulative risk for exposure to carcinogens is 3.65E-04, greater than the acceptable risk of 1.0E-04. The cumulative risk for exposure to carcinogens will be re-evaluated after addressing the areas with lead and benzo(a)pyrene above the calculated site-specific values.

Soil Greater Than 2 Feet Below Grade

- The direct contact pathway to soil greater than 2 feet beneath the ground surface at the refinery is incomplete because of on-site procedures and PPE requirements that protect onsite workers from exposure.

CAMU Area

- Several COCs were detected above the MSCs in the waste material and in the soil beneath the waste material. However, only low concentrations of benzene, chrysene, naphthalene and lead were detected in groundwater beneath or around the CAMU areas. Therefore, the constituents in the waste materials above the MSCs do not appear to have a significant impact on groundwater quality beneath and around the CAMU areas. Therefore; Sunoco is requesting that EPA issue a comfort letter for the CAMU in AOI 10 regarding the characterization work completed.

GROUNDWATER

- Fate and transport calculations were completed for groundwater in AOI 10 to evaluate potential migration pathways/potential impacts to receptors. Eight wells (W-1, W-12, W-23, W-28, W-31, W-32, W-33, and W-34) in AOI 10 exhibited concentrations of groundwater COCs above their respective MSCs. The results from these wells were modeled using the QD model to determine whether COC concentrations could potentially reach the AOI 10 boundary. The modeling results indicate concentrations above the groundwater MSCs in shallow wells W-1, W-12, W-23, W-28, W-31, W-32,

and W-34 are not predicted to migrate beyond the AOI 10 boundary, with the exception of one well, W-33, which contains a concentration of benzene that has the potential to reach Lands Creek. However, the predicted benzene concentration at the Lands Creek boundary is below the 25 Pa. Code Chapter 93 surface water quality criteria for benzene.

- Excavations in AOI 10 are governed by Sunoco's permitting procedures which protect against potential exposures to groundwater that could be encountered in an excavation.

SOIL VAPOR

- There are no occupied buildings in AOI 10.
- The results of the vapor intrusion screening evaluation using the PADEP guidance and the soil data collected (where the groundwater table is greater than five feet) indicate that no soil analytical results in AOI 10 are above the non-residential EPA/PADEP default screening values or the OSHA PEL screening values.
- No soil gas sampling was completed as part of this site characterization, but if future development is proposed for the areas that were not able to be screened using the PADEP vapor screening criteria, soil gas sampling would be completed in these areas.

LNAPL

- LNAPL occurrence in AOI 10 is limited to wells W-8, W-14 and W-18 and is immobile.
- There is poor correlation between areas with LNAPL and dissolved COCs in groundwater nearby.
- There are no complete direct contact exposure pathways for LNAPL within AOI 10 because of on-site permitting procedures and required PPE.

SURFACE WATER

- No COCs were detected in the surface water samples collected from Lands Creek at concentrations above their respective 25 Pa. Code Chapter 93 screening criteria.

SEDIMENT

- Based on the ecological screening evaluation, additional work needs to be completed to determine if the threatened and endangered species listed in PNDI receipt, or suitable habitat for these species, exist within a 1,000 foot radius of the site. This work will be completed in support of, and documented in, the Cleanup Plan for AOI 10.

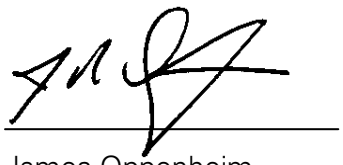
12.0 SCHEDULE

The proposed schedule for future Site activities is:

- Submittal of a Cleanup Plan within 6 to 12 months following PADEP approval of the SCR/RIR;
- Submittal of an Act 2 Cleanup Plan and Final Report; and
- Continue quarterly monitoring activities and reports.

13.0 SIGNATURES

The following parties are participating in the remediation at this time and are seeking relief from liability under Act 2 of 1995:



James Oppenheim
Sunoco Inc. (R&M)

This Act 2 RIR has been prepared in accordance with the final provisions of Act 2 and the June 8, 2002 Land Recycling Program Technical Guidance Manual.

14.0 REFERENCES

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